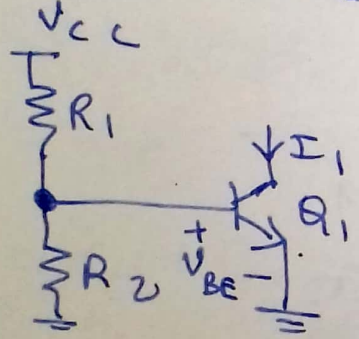
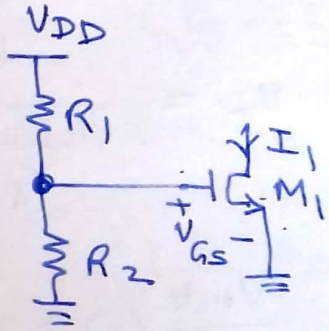
CURRENT SOURCE :-

Cascode :- "Cascaded Triodes having similar characteristics to a Pentode"

"Coined in 1939"

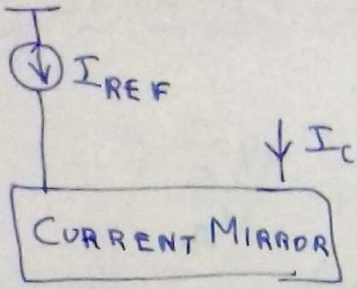
Impractical Realization of Current sources :-

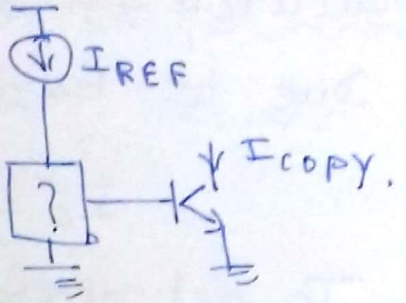


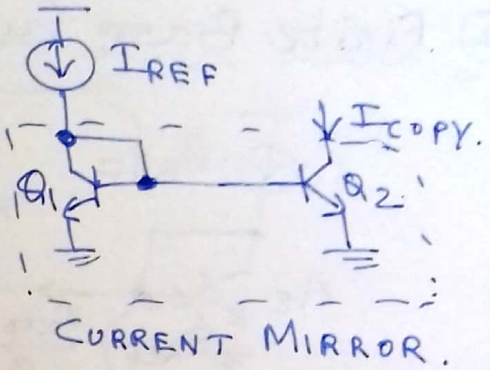


$$\frac{R_2}{R_1+R_2} V_{CC} = V_T \ln\left(\frac{I_1}{I_S}\right)$$

$$\frac{R_2}{R_1+R_2} V_{DD} = \sqrt{\frac{2I_1}{\mu_n C_{ox} \frac{W}{L}}} + V_{TH}$$

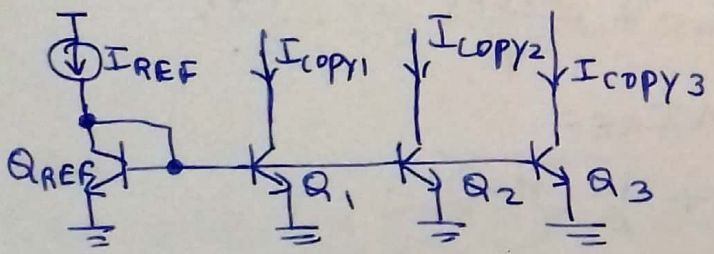


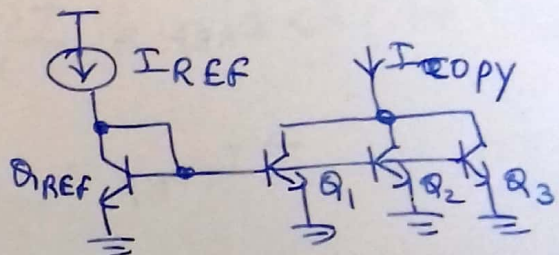


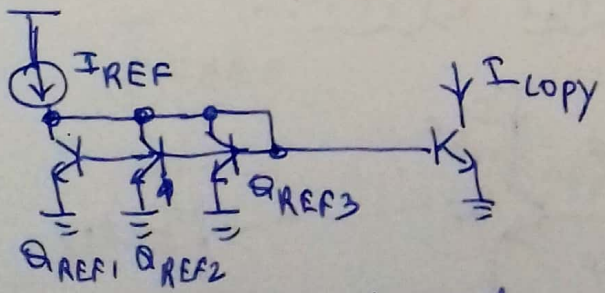


Properties of Current Mirrors

1. High output impedance.
2. Low compliance voltage. → compliance voltage is the voltage across the current mirror.
3. Accuracy of mirroring.

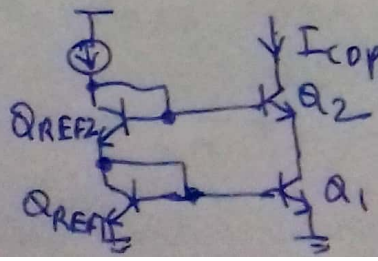






How to increase o/p impedance?

* Cascoding.



* Mirroring action due to Q_1.
* Enhanced o/p impedance due to Q_2.

(3)

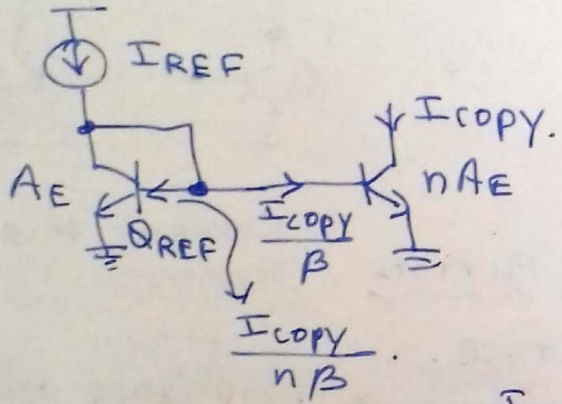
Inaccuracy In BJT Current Mirrors :-

(1) Due to Early Voltage :-

$$I_C = I_C e^{\frac{V_{BE}}{V_T}} \left(1 + \frac{V_{CE}}{V_A}\right)$$

To get perfect (i.e., 100%) accuracy V_{CE} of Q_{REF} should be equal to $V_{CE,copy}$ transistor

(2) Finite Base Current :-

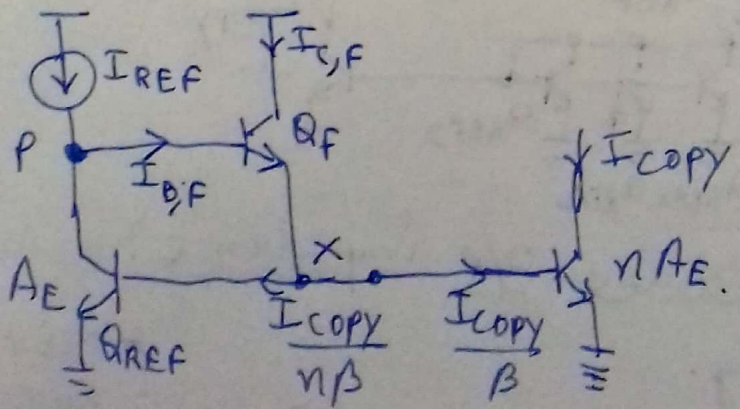


Thus, $I_{REF} = I_{CREF} + \frac{I_{copy}}{n\beta} + \frac{I_{copy}}{\beta}$.

$$\Rightarrow I_{REF} = \frac{I_{copy}}{n} + \frac{I_{copy}}{n\beta} + \frac{I_{copy}}{\beta}.$$

$$\Rightarrow I_{copy} = \frac{n I_{REF}}{1 + \frac{1}{\beta}(n+1)}.$$

Minimizing this error :-



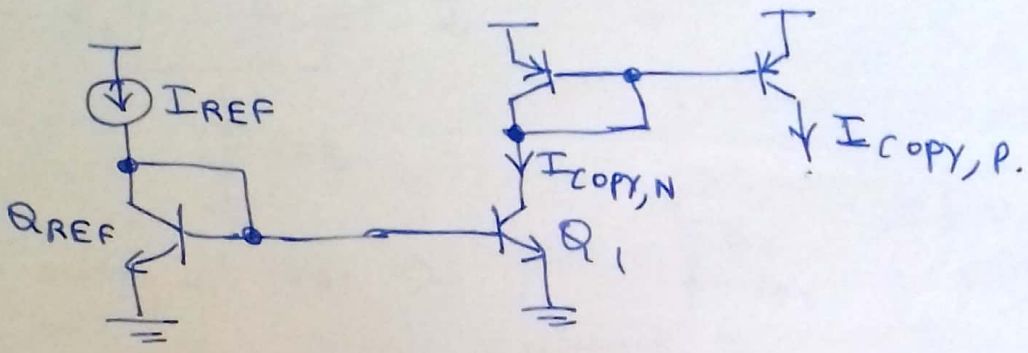
Now, $I_{SF} = \frac{I_{copy}}{\beta}\left(1 + \frac{1}{n}\right) \Rightarrow I_{B,F} = \frac{I_{copy}}{\beta^2}\left(1 + \frac{1}{n}\right)$.

Thus, $I_{REF} = I_{B,F} + I_{C,REF}$.

$$\Rightarrow I_{REF} = \frac{I_{copy}}{\beta^2}\left(1+\frac{1}{n}\right) + \frac{I_{copy}}{n}.$$

$$\Rightarrow I_{copy} = \frac{n\, I_{REF}}{1+\frac{1}{\beta^2}(n+1)}$$

How to make PNP mirrors?

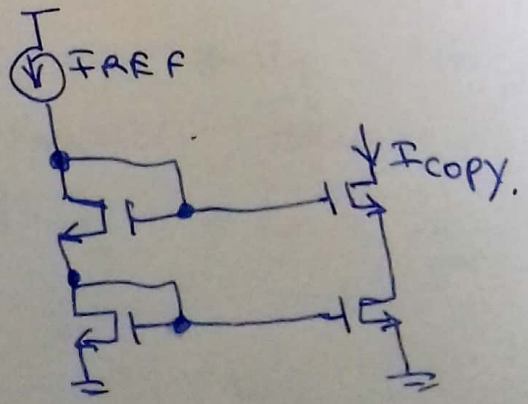


Inaccuracy in MOS Current Mirrors

* Due to mismatch in V_{DS} of the reference and copying transistor.

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2(1+\lambda V_{DS})$$

Cascode Current Mirrors :-



* PMOS current mirrors can be realized similar to PNP mirrors shown above?